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METHOD OF WIRELESS DATA EXCHANGE AMONGST DEVICES OF LIMITED RANGE

FIELD OF THE INVENTION

The method is relates generally to the wired and wireless communications, LANs, and more particularly to a service communication management and output power control for providing high quality connection in peer devices, according to said estimation a quality connection level between them is estimated, then an appropriate signal output level is chosen depending on the estimation result.

BACKGROUND OF THE INVENTION

Routing Method

The present invention relates to a novel routing method specifically adapted for use with ad-hoc heterogeneous mobile networks and more particularly though not exclusively to a routing method where communications between source and destination mobile units is carried out across a conference size packet radio network of mobile units.

Ad-hoc heterogeneous mobile networks have recently become important in the field of mobile communications particularly with respect to mobile computer supported collaborative work. An Ad-hoc heterogeneous mobile network comprises a plurality of mobile units each being able to communicate with its neighboring mobile units which are situated one hop aside. In this case each mobile unit acts as a router relaying packets of information from one mobile unit to another.

Ad-hoc heterogeneous mobile networks differs from infra-structured wireless local area networks since they do not have access to base stations. Moreover, in ad-hoc heterogeneous mobile network, the mobile units are always to be able to communicate with each other over a wireless or wired media no network administrative component support. Thus, one of the most important features of any routing method or protocol for an ad-hoc mobile network, is the ability to settle and vary link

changes, namely changes connection between mobile units due to mobile units' migrations. However, conventional distributed routing schemes attempt to maintain consistent routing information by performing periodic link and topology updates. These updates are undesirable because of the frequent link changes occurring in ad-hoc heterogeneous mobile networks can result an enormous number of transmissions over the wireless and wired media to propagate and update routes. This is highly impractical, inefficient and results low data throughput in an environment where bandwidth and hardware are scarcely in resources.

One of the earliest deployments of a regional-wide wireless data network was the ARPANET Packet Radio Network (PRN) by Kohn, Gronemeyer, Burchfiel and Kunzelman. As shown in FIG. 2, all components (repeaters R. terminals T and station S) in a PRN can be mobile or certain components can remain fixed while others are moving. There are two approaches used in a PRN for routing and packet forwarding. In "point-to-point" routing, the station computes all the routing information and the decision is either distributed to the repeaters involved in the route or to the source. This scheme is only suitable for slow moving user terminals. However, in "broadcast routing", each packet radiates away from the source with a wave-front-like propagation. Since no station needs to be present to compute routes, the destination address serves to identify the intended recipient. For fast moving user terminals, broadcast routing is preferred over point-to-point routing as it avoids the need to process rapidly changing routes.

In the connectionless approach to packet forwarding, some background operation is required to maintain up-to-date network topology and link information in each node. Accordingly, as network topology changes, the background routing traffic required in using the connectionless approach can be substantial. The connectionless approach is commonly associated with broadcast routing, where each packet carries sufficient

routing information for it to arrive at the destination. However, in the connection-oriented approach, an explicit route establishment phase is required before data traffic can be transported. The connection-oriented approach is commonly associated with point-to-point routing, where each node in a route has a look up table for forwarding incoming packets to the respective out-going links. The disadvantage of the connection-oriented approach is that if the network topology changes, a route re-establishment phase is required.

Several ad-hoc mobile routing schemes have evolved over the past few years. Most of these schemes are based on either broadcast or point-to-point routing using either the connectionless or connection-oriented packed forwarding approach.

The "Layer Net" self-organizing protocol proposed by Bhatnagar and Robertazzi uses a connectionless packet forwarding approach. Broadcast routing is used for the initial network connectivity construction and the subsequent topology maintenance as a result of nodes' movements and link changes. Network topology updates have to be performed in sympathy with link changes and routes are not constructed based on demand. Accordingly, the overall signaling traffic can be quite substantial.

Cluster-based routing by Krishna, Chatterjee, Vaidya and Pradhan uses the broadcast routing and connectionless packet forwarding approach. Cluster-based routing relies on existing routing schemes such as link-state or distance-vector routing to derive network topology and link information. In addition, a clustering methodology is used to reduce the number of updates due to mobile units' migrations. Routes are constructed between all pairs of nodes and route maintenance is essentially cluster maintenance. The disadvantage of cluster-based routing is that the method is inefficient.

Source-initiated distributed routing by Corson and Ephremides uses a combination of point-to-point and broadcast routing

using the connection-oriented packet forwarding approach. Here routes are initiated by the source and are constructed based on demand, and so this method forgoes the need to constantly propagate up-to-date routing information throughout the network. However, because alternate route information is used during route re-construction, problems associated with stale routes exist.

Dynamic source routing for mobile networks by Johnson avoids periodic route advertisements because route caches are used to store source routes that a mobile unit has learnt over time. A combination of point-to-point and broadcast routing using the connection-oriented packet forwarding approach is used. Routes are source-initiated and discovered via a route discovery protocol. With source routing, the sender explicitly lists the route in each packet's header, so that the next-hop nodes are identified as the packet travels towards the destination. Cached route information is used and accurate updates of these route caches are essential, otherwise routing loops can occur. Since the sender has to be notified each time a route is truncated, the route maintenance phase does not support fast route reconstruction.

Fail Safe Filing System Method

The method of increasing fault tolerance of a file system for carriers with a limited recording operation resource consists in dividing all carriers volume into identical size and format blocks. Each block of the carrier is assigned a logical number and a block occupation attribute. In case of a failure of a block to record the data, the system searches for another free block and makes record. In case of system failure, the damaged data is localized in one block and causes no damage to all file. Lost data can be easily restored automatically.

SUMMARY OF THE INVENTION

Routing Method

The main subjects of the invention concerning routing method are

- an improved routing method that provides efficient and high throughput communication between mobile units in an ad-hoc mobile network and which can deal efficiently with mobile units' migrations that effect the validity of routes through the mobile network.

- a routing method that avoids network congestion due to unfair burdening of a particular mobile unit to support many routes and to perform many data relaying functions.

- a routing method able efficiently to handle concurrent movement of a plurality of mobile units in an ad-hoc mobile network.

- a routing method able readily to incorporate new mobile units into the ad-hoc network without requiring vast amounts of information about the new mobile unit.

- a routing method which avoids packet duplicates, stale routes, loops and deadlock, but does this efficiently without requiring vast amounts of memory, bandwidth or power.

Briefly stated, these objects are attained in a routing method in which the cumulative forwarding speed through an ad-hoc mobile communications network is estimated and selection of a particular route for transmission of information is based on that cumulative forwarding speed.

The cumulative forwarding speed, which is simply a measure of the quality of service between neighboring mobile units, is estimated for each route on sending the query request.

More particularly, according to one aspect of the present invention there is provided a routing method for supporting ad-hoc mobile communications within a communications network, the network comprising a plurality of mobile units including a source mobile unit and a destination mobile unit and a plurality of communication links connecting together said

plurality of mobile units, said method comprising: sending a query request to search for available routes from source to destination mobile units, selecting the route, requiring the minimum time for information signal to reach destination mobile unit.

In an embodiment of the present invention, associativity tables are provided at each mobile unit, each associativity table storing the list of possible mobile units reachable via each accessible neighboring mobile unit.

Each mobile unit optionally comprises an additional routing data for passing information signals through the mobile unit from one of its neighbors to others of its neighbors. The routing tables advantageously enable the mobile units to be arranged to support a plurality of routes through the network between various source and destination mobile units. In addition, each mobile unit optionally has the ability to store route relaying load information regarding the total number of selected routes supported by the mobile unit.

Seen tables may also be provided at each mobile unit. Each seen table records identifier data regarding information signals that had already passed through the mobile unit. The seen tables can then be used to discard information signals that have previously passed through the mobile unit. In case when the information signal is formed in data packets, the said seen tables can avoid duplicate packets passing through each communication link.

The routing method optionally comprises a data flow acknowledgement mechanism comprising acknowledgements. The acknowledgement comprises receiving at a mobile unit an information signal previously sent by the mobile unit to one of its neighboring mobile units and which has been retransmitted back thereby. In this case, signal is retransmitted by the destination mobile unit. The data flow acknowledgement may optionally include retransmitting the previously sent signal

from the mobile unit to the neighboring mobile unit if an acknowledgement is not received within a predetermined period.

A procedure for restoring a selected communications route which has been invalidated due to movement of a mobile unit previously supporting the selected route, the restoring procedure establishing a new route through the network based on the previously found routes or on new route search and selection on the cumulative forwarding speed method.

Global Message Transport (GMT)

GMT method aims to solve the task of expanding the coverage area for remote transmission and reception of information for networking clients equipped with a mobile device combined with a limited-range radio transceiver. The method increases the data communication efficiency between subscribers, including possibility of world-wide message exchange.

Frequency Division Multiple Access Method

Proposed Frequency Division Multiple Access method allows the maximal use of assigned channel band for increasing total data exchange speed, decreasing the idle time by means of dividing of all or a part of assigned band into two or more frequency channels with the further assigning them different functions in the data exchange process.

The method lies in assigning each frequency channel the different types of jobs to be processed at.

Output Power Control

A output power control method in RF communication systems is either proposed. Every device the receives a data block from other device checks its RSSI level and if the level is lower than a threshold, the remote device is signed as 'distant'. Then all data blocks to be sent directly to that device should have higher level of transmitting power indicating it in the frame header. If a frame from 'faraway' device is received with high level of RSSI, the device is signed a 'normal'. An RSSI

measured value should be corrected in accordance with indication of extra power in a frame header.

Fail Safe File System

A method for increasing fault tolerance of a file system for carriers with a limited recording operation resource and a protected file system for carriers with a limited recording operation resource

The method of increasing fault tolerance of a file system for carriers with a limited recording operation resource consists in dividing all data carrier's area into information blocks identical in size and format. Each block of the carrier is assigned a number of attributes: a block occupation attribute; file identifier; logical number of the block into a file; and the data fullness of block. For the first block of the file the file name is being additionally included. In case of a failure of a block with a specific logical number to record the data, the system searches for another free block and make data record there, the damaged block is being marked by special attribute.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawings, wherein:

FIG.1 is a schematic diagram showing possible applications of present methods.

FIG. 2 is a schematic diagram showing the prior art arrangement of a Packet Radio Network;

FIG. 3 is a graphical representation showing how the general property of associativity of a mobile unit with its neighbors' varies with time and space;

FIG. 4 is a schematic diagram showing how the merging of two communication sub-nets forms a larger communication network;

FIG. 5 is a schematic diagram showing how the associativity metric is utilized during a route discovery procedure of an embodiment of the present invention;

FIGS. 6 and 7 are schematic diagrams showing how interruptions in a REPLY packet propagation route are dealt with in the embodiment of the present invention;

FIGS. 8, 9 and 10 are schematic network diagrams respectively showing how a Route Reconstruction Phase of the embodiment of the present invention operates when a source, destination and intermediate mobile unit migrate;

FIG. 11 is a schematic diagram showing how the BQ seen table entry is erased in the embodiment of the present invention;

FIG. 12 - 14 are a schematic diagrams illustrating GLOBAL MESSAGE TRANSPORT method.

DETAILED DESCRIPTION OF THE INVENTION

A method of wireless data exchange amongst ad-hoc mobile devices of limited range within a communications network is described here. The network comprises a plurality of mobile units including a source mobile unit and a destination mobile unit and a plurality of wireless communication links wirelessly connecting together. The described method comprises

- a special communicative protocol supporting a plurality of tasks in connection with ad-hoc network abilities (hereinafter CYRF protocol);
- a special communicative protocol supporting a plurality of tasks on global communications (GLOBAL MESSAGE TRANSPORT) (hereinafter GMT);
- fail-safe file system.

The said CYRF communicative protocol further comprising

- a routing method for providing data exchange among devices in network,
- a frequency division multiple access method,
- RF output power control method.

FIG. 1 shows possible performance of the abovementioned methods.

Routing Method

Method of the present embodiment is hereinafter referred to a method and protocol for supporting ad-hoc mobile computing within a radio communications network embodying the present invention. The communications network comprises a plurality of mobile units including a source mobile unit and a destination mobile unit, and a plurality of radio communications links connecting together the mobile units.

Every ad-hoc mobile network comprises a source mobile unit (source node) which desires to transmit information across the network, a destination mobile unit (destination node) which is the intended recipient of the information, and intermediate mobile units (intermediate nodes) which are configurable to

relay the information between the source node and the destination node. For the sake of clarity, hereinafter the direction from the source node to the destination node will be referred to as downstream and the direction from the destination node to the source node as upstream. Movements of any of these mobile units (source, destination or intermediate nodes) can affect the validity of a selected communication route directly as shown in Fig.3.

A source node in a route has a downstream link and when it moves out of its downstream neighbor's radio coverage range, the existing route will immediately become invalid. Hence, all the downstream nodes may have to be informed so as to erase their invalid route entries. Likewise when the destination node moves out of the radio coverage range of its upstream neighbor, the route becomes invalid. However, unlike the earlier case, the upstream nodes will have to be informed so as to erase their invalid route entries. In addition, any movements by one of the intermediate nodes supporting an existing route may cause the route to become invalid. In reality, concurrent moves by source, destination and intermediate nodes exist and require multiple responses by the routing protocol. All these nodes' movements cause many conventional distributed routing protocols to respond in sympathy with the link changes, in order to update all the remaining nodes within the network so that consistent routing information can be maintained. This involves broadcasting over the wireless medium which disadvantageously results in wasteful bandwidth and an increase in the overall network control traffic. However, use of the higher summarized query signal speed as a main decisive characteristic in route selection avoids all prior art disadvantage.

Referring to FIG. 4, there is shown a merged subnet 13 of mobile units 2. The merged subnet 13 comprises two subnets 14,15 linked by a subnet bridging mobile unit 16. Moves by a mobile unit 16 which is performing subnet-bridging function between two mobile subnets 14,15 can fragment the merged mobile

subnet 13 into smaller subnets 14,15. The property of a mobile subnet states that if both the source node and destination node are part of the same subnet, a route or routes should exist unless the subnet is partitioned by some subnet-bridging mobile units 16. On the other hand, moves by certain mobile units can also result in subnets 14,15 merging, giving rise to bigger subnets 13 as is illustrated in FIG. 4. When the mobile subnets 14,15 merge to form bigger subnets 13, the routing protocol may typically accept the new subnet 13 by updating all the nodes' routing tables but this is very inefficient. However, use of the cumulative forwarding speed is much more efficient and easy to realize because it automatically, without additional preliminary steps, shows the route with the best integral quality of service through the route. Likewise, this applies to partitioning subnets.

From an application perspective, mobile subnets can be used to support nomadic collaborative computing, and the collaboration partners can grow in size when two collaborating groups join or when new mobile users join by coming into range.

Turning now to the embodiment of the present invention, the method comprises measuring the stability of the communications links between neighboring mobile units using the cumulative forwarding speed characteristic and selecting a communications route through the network from the source mobile unit to the destination mobile unit based on the stability of the communications links. Use of the cumulative forwarding speed characteristic also enables the routing method to deal effectively with route invalidation caused by mobile unit migrations.

The method of the present embodiment is hereinafter referred to as Cybiko Radio Frequency Protocol (CyRF). CyRF is a compromise between broadcast and point-to-point routing and uses the previously mentioned connection-oriented packet forwarding approach. CyRF only maintains routes for source mobile units that actually desire routes. CyRF employs route

reconstruction based on alternative route information stored in intermediate nodes, which simplifies route reconstructions.

The CyRF protocol comprises three different phases, namely a Route Discovery phase, a Route Reconstruction Cycle (RRC) phase and a Route Deletion phase.

Initially, when a source node desires a route, the route discovery phase is invoked. When a link of an established route changes due to source node, destination node, intermediate node or subnet-bridging mobile units migration, the RRC phase is invoked. When the source node no longer desires the route, the route deletion phase is initiated.

The route discovery phase allows an approximation of the data throughput associated with the selected route to be computed. This is achieved through the knowledge of ticks' regularity of neighbors in the route and a relaying load of each node supporting the route a parameter provided at each node in the network. The route discovery phase consists of a broadcast query (BQ) and await reply (REPLY) cycles.

BQ-REPLY cycle

Initially, all nodes except those of the destination node's neighbors have no routes to the destination node. A node desiring a route to the destination node broadcasts a BQ packet, which is propagated throughout the ad-hoc mobile network in search of mobile units, which have a route to the destination node. A sequence number (SEQ NO.) is used to uniquely identify each BQ packet and no BQ packet is broadcast more than once.

Referring now to FIG. 5, once the BQ packet 18 has been broadcast by the source node 20, all neighboring nodes 01, 02, 03, IS1 that receive the packet 18 check if they have previously processed the BQ packet 18. If affirmative, the BQ packet 18 is discarded, otherwise the neighboring node 01, 02, 03, IS1 checks if it is the destination node 24. If it is not the destination node 24, the neighboring node 01, 02, 03, IS1 appends its mobile unit address 26 at the intermediate node

identification (ID) field of the BQ packet 18 and broadcasts it to its neighbors (if it has any).

The retransmissions from the neighboring nodes 01, 02, 03, IS1 all return back to the source node 20 where they are discarded. However, one of the neighboring nodes IS1, which is called an intermediate node 22, transmits the BQ packet 18 to its neighboring nodes T1, IS2 where the above described procedure is repeated.

The next succeeding intermediate node 22, IS2 will then erase its upstream node's neighbors' associativity ticks entries 28 and retain only those concerned with itself and its upstream node. In addition, because of the association ticks 28 symmetry between all nodes, the associativity ticks 28 received from the upstream node can be checked for validity.

In this manner, the BQ packet 18 reaching the destination node 24 will only contain the intermediate mobile units addresses 26 (hence recording the route 30 taken) and the route relaying load, together with information on route propagation delays and hop count. (The route hop count can be deduced from the number of intermediate nodes 22 in the route 30).

The destination node 24 will, at an appropriate time after receiving the first BQ packet 18, know all the possible routes 30 and their qualities. Given a set of possible routes 30 from the source node 20 to the destination node 24, if a route 30 consists of mobile units with known quality level expressed as a cumulative forwarding speed, then that route 30 (the first received) will be automatically chosen by the destination node 24, despite other less fast routes. However, if the overall speed along two or more routes 30 are practically the same, the number of hopes and quality of service between links will be taken into consideration on the route selection.

The route parameters that govern the CyRF route selection are: (a) route relaying load, (b) route length and (c) cumulative forwarding delay. The forwarding delay refers to all processing, queuing, carrier sensing and transmission delays.

Forwarding delay measurements are exponentially smoothed and stored on a per-neighbor mobile unit basis, as in PRNs. The cumulative forwarding delay, therefore, reflects the end-to-end delay of the route concerned. However, the order of "route ordering" (i.e., which route metrics are regarded as more important than others) may change and is dependent upon the application quality of service specification.

Once the destination node 24 has selected the best route a REPLY packet (RP) is sent back to the source node 20 via the route 30 selected. This causes the intermediate nodes 22 in the route 30 to mark their routes to the destination node 24 as valid. All other possible routes are then inactive and will not relay packets destined for the destination node 24 even if they hear the transmission. This, therefore, avoids duplicated packets from arriving at the destination node 24. Once a route has been selected, each of the intermediate nodes 22 in the network can be classified as active if it supports the chosen route 30 or inactive if it does not support the chosen route 30.

While the BQ packet 18 propagates to the destination node 24 each intermediate node 22 relaying the BQ packet 18 will know its quality of service from the source node 20. Likewise, when the REPLY packet (RP) propagates back to the source node 20, the intermediate nodes 22 can also compute their quality of service to the destination node 24.

The RP is similar to the BQ packet 18 but may omit some fields.

When the RP reaches the source node 20, the route 30 is established. The source node 20 can then proceed with data transmission over this route 30, where packets will be forwarded from one intermediate node 22 to another until they arrive at the destination node 24. Issues related to packet header and routing table formats, data acknowledgement and re-transmission are discussed later in this description.

Route Reconstruction (RRC) Phase

In the CyRF protocol, the selected route 30 is more likely to be the fastest due to the property of cumulative forwarding speed. However, if unexpected moves do occur, the RRC phase procedures will attempt to quickly locate an alternative valid route. The RRC phase of the CyRF protocol essentially performs four operations: partial route discovery; invalid route erasure; valid route update; and new route discovery (in the worst case). These operations may be invoked by any of the four node moves mentioned earlier.

Referring now to FIGS. 6 and 7, the way in which the RRC phase can be invoked during the BQ-REPLY cycle is explained. There may be some rare instances when the source node 20 never receives the RP because of some unexpected "not-yet-selected" intermediate node's 54 movement as shown in FIG. 6. In such circumstances, the source node 20 will eventually time out (BQ-TIMEOUT) and send another BQ packet 18. Since the downstream neighbor 53 of the migrating intermediate node 54 realizes the associativity change, it will send a route notification packet in the downstream direction, deleting all the downstream nodes' invalid routing table entries. Another situation occurs when a selected intermediate node 54 moves while the RP propagation is still in progress (see FIG. 7). The upstream neighbor 56 of the migrating node 54 will perform a localized query process to discover a new partial route, while the downstream neighbor 53 sends a route notification packet towards the destination node 24, thereby erasing all invalid downstream nodes' routing entries.

Turning now to the consequence of node movements after a valid route 30 has been established by the BQ-REPLY cycle, FIGS. 8, 9 and 10 show respectively how the movements of the source node 20, the destination node 24 and intermediate nodes 22 are dealt with in the RRC phase.

FIG. 8 shows a network of mobile units comprising a source node 20, a destination node 24, intermediate nodes 22 and the various communication links 60 therebetween. The valid route 30

from source node 20 to destination node 24 has previously been established by a broadcast query. In the event of any movement by the source node 20, the RRC phase carries a route re initialization process via a broadcast query 58. This is the simplest and most efficient way of establishing a new route 62 to the destination node 24 and it also advantageously avoids multiple RRC phase conflicts as a result of concurrent nodes' movements.

Referring now to FIG. 9, when the destination node 24 moves, the destination node's immediate upstream neighbor 64, or so called, pivoting node 64, will erase its route.

The pivoting node 64 then performs a localized query (LQ[S]) process to ascertain if the destination node 24 is still reachable. "S" here refers to the forwarding speed from the pivoting node 64 to the destination node 24. If the destination node 24 receives the localized query (LQ) packet, it will select the best partial route (the first received) and send a RP back to the pivoting node 64, otherwise a time out period (LQ.sub.-- TIMEOUT) will be reached and the pivoting node 64 will backtrack 66 to the next upstream node.

The migration of a subnet-bridging mobile unit 16 beyond the radio coverage of its neighboring mobile units 2 will cause the mobile subnet 13 to be partitioned (see FIG. 2). If an existing route 30 does not span across the fragmented subnets 14,15, the route 30 is not affected and only the subnet-bridging mobile unit's upstream and downstream neighbors need to update their route and associativity entries. All other mobile units remain ignorant and do not perform any route updates. However, if existing routes 30 span across subnets i.e., the subnet-bridging mobile unit 16 is an intermediate node 22 of the route 30, then the route 30 is invalidated as the destination node 24 is no longer reachable, despite any LQ process 70 or BQ-REPLY cycle attempts. Under such circumstances, the localized query and route notification cycle will eventually inform the source node 20 about the partitioning and the source node 20 can then

invoke BQ-REPLY cycles several times or it can inform the mobile user about the partitioning and prompt him or her to try later.

Race conditions exist due to multiple invocations of RRC procedures as a result of concurrent movements by the source node 20, the destination node 24 and intermediate nodes 22. The following explains how the CyRF of the present embodiment is immune to "multiple-RRC procedures" conflicts and how one RRC procedure is valid ultimately.

Destination Node Migration RRC Procedure Interrupted by Upstream Intermediate Node Migration

When the destination node 24 moves and while the RRC procedure is in progress, any upstream intermediate node moves will cause their respective downstream neighbors' route to be deleted. The new pivoting node 64 nearest to the source node 20 will perform the RRC procedure and all other RRC procedures will be passive when they hear the new LQ broadcast for the same route. Hence, only one RRC procedure is valid.

Upper-Arm Intermediate Node Migration RRC Procedure Interrupted by Lower Arm Intermediate Node Migration

This situation is resolved in the same way as the above-mentioned situation. Note that the same argument can be applied to the case when a LQ process 70 has to be aborted and a RN[1] control packet 73 has to be sent to the source node 20 to invoke a BQ-REPLY cycle but is hindered due to some upstream intermediate node's movements. The new pivoting node 64 nearest to the source node 20 will swamp the earlier RRC procedures by invoking a new LQ process 70.

Lower-Arm Intermediate Node Migration RRC Procedure Interrupted by Upper Arm Intermediate Node Migration.

While a lower arm intermediate node migration RRC procedure is taking place, any movements by any upper arm intermediate nodes 22 will not result in a LQ[S] or a RN[1] process being initiated since a lower arm intermediate node 22 has earlier sent an RN[1] control packet 73 downstream to erase invalid

routes. If the RN[1] control packet 73 does not succeed in propagating to the destination node 24, the LQ[S] process 70 initiated by the lower arm intermediate node 22 will also serve to delete these invalid routes.

Intermediate Node Migration RRC Procedure Interrupted By Destination Node Migration

This has no effect on the RRC procedure, as the LQ[S] process 70 uses a localized query approach to locate the destination node 24. Once the destination node 24 is associatively stable and is reachable from the pivoting node 64, the RRC procedure will be successful.

Intermediate Node Migration RRC Procedure Interrupted By Source Node Migration

While lower or upper arm intermediate node migration RRC procedure is in progress, any moves by the source node 20 will result in a BQ-REPLY cycle, which will swamp out all on-going localized query, REPLY and route notification processes related to that route. Hence, unfruitful and stale RRC procedures will not continue and a new route will be discovered via the BQ-REPLY cycle.

Source and Destination Nodes Moving Away from Intermediate Nodes

When this occurs, RRC procedures as a result of destination node and source node migration will be initiated. However, the BQ-REPLY cycle initiated by the source node 20 will again swamp out all unnecessary ongoing RRC procedures.

Destination Node Migrating Into Source Node's Radio coverage Range

When the destination node 24 migrates, RRC procedure is achieved via the LQ[S] process 70. However, when the destination node 24 is within the source node's radio coverage range, packet duplicates will result at the destination node 24 since the destination node 24 now receives packets from the source node 20 directly and also from the original source node 20 to destination node 24 route. Hence, to avoid packet

duplicates and non-optimal routes, the source node 20, on discovering that the destination node is within range and is in stable state, will send a RN[1] control packet 73 downstream to erase the existing route and will re-establish a new single hop route with the destination node 24.

During a LQ-propagation and REPLY-await process, if any of the upstream nodes (i.e., lower arm intermediate nodes 22) break up, an RN[1] control packet 73 will be propagated downstream, erasing all the downstream intermediate nodes' route entries. The existing pivoting node 64 will ignore any subsequent REPLY to its LQ process. The new pivoting node 64 will resume with a new LQ and REPLY process. It should be noted that downstream nodes' migrations are not of concern during the LQ and REPLY process.

In CyRF, alternate routes are retained. Only one route will be selected and other routes are valid for a particular route request.

Any alternate route may be discovered via a LQ or BQ process as well, which may give rise to better (speed, or quality of service) routes. The destination node 24, on receiving multiple BQ or LQ packets, will select the best route (the first received) and reply to the source node 20.

Finally, for the case of a BQ process, any intermediate nodes 22 receiving a BQ packet 18 and having invalid routes will have their invalid routes erased, therefore ensuring that no invalid routes exist in the intermediate nodes 22.

Route Deletion Phase.

When a discovered route 30 is no longer desired (when the time out period expired), all route on all SRC, intermediate and DEST nodes. All nodes 22 update their routing table entries. It even does not depend on transmittal process completion.

To prevent mobile units 2 from processing and relaying the same BQ, LQ or RD packet 18, 80 or 82 twice, BQ, LQ and RD seen tables are provided. If the received control packet type 32,

route identifier source and destination node addresses 34,36 and sequence number 45 match an entry in the seen table list, then the packet is discarded. The contents of these seen tables are erased after a certain time-out period. This time-out period is long enough to allow a mobile unit's neighbors to forward the BQ, LQ or RD control packet 18, 80, 82 to their corresponding neighbors, as illustrated in FIG. 11. More particularly, a mobile unit Na having transmitted it BQ(1) control packet to its neighbors Nb, Nd, will hear transmissions from those neighbors Nb, Nd, when they forward the BQ(2) control packets to their neighbors. Hence, the BQ(2) packets will be ignored by the mobile unit Na. The BQ(1) entry in the BQ control seen table of mobile unit Na, is not erased until at least after the end of the period of receiving passive acknowledgements from all of the neighbors Nb, Nd of the mobile unit Na.

On the other hand, because the RP and RN control packets utilize time out period, seen tables for these packets are not necessary.

As to data flow acknowledgement and packet transmission, the present embodiment of the invention implements end-to-end flow control by adopting the scheme used in PRNs, namely an acknowledgement scheme for packets in transition. When a node receives a packet and performs relaying via a radio transmission to its neighbors, its previous neighbor that has sent it the packet will have heard the transmission and hence this is indirectly used as an acknowledgement to the packet sent. Hence, this provides a data flow acknowledgement mechanism for packet forwarding in an ad-hoc mobile network.

The present embodiment of the invention includes a unit discovery mechanism. When an associativity is formed (through recognizing a neighboring mobile unit's identifier beacon), a mobile application controlling the network is informed of the new mobile user who can then participate in nomadic collaborative computing. The new associativity of one mobile

unit with another can also be propagated to the nodes' neighbors, so that all other neighboring mobile units within the mobile subnet can be made aware of the existence of the new user. Alternatively, a mobile unit can choose only to be aware of its immediate neighbors and can later perform an on-demand neighbor discovery broadcast when it desires to communicate with mobile units outside its vicinity. As a result of network connectivity, a mobile unit can also discover what services are available from which other mobile units.

The assessment of the quality of a particular route, as is carried out in the BQ process at the destination node 24 on receiving BQ packets 18, requires analysis of various routing qualities.

The longevity of a route is not important, due to specific of the mobile networks. Though the fast route reconstructions are to be planned. In addition, even relaying load distribution is important in an ad-hoc mobile network, as no one particular mobile unit should be unfairly burdened to support many routes and perform many packet-relaying functions. This latter characteristic also helps to alleviate the possibility of network congestion. Finally, since the associativity of a mobile unit with its active or inactive neighbors and the route relaying load, i.e. the total number of active routes supported by the mobile unit also reflect the number of contenders within a wireless cell, the approximate aggregated throughput (link capacities) for the selected route can be made known to the mobile user prior to transmission, therefore allowing the user to either proceed with or abort the transmission.

The present embodiment can also be integrated with Wireless Global Networks (WWW) via Wireless Internet Gate (WIG) stations (see FIG.12). In fact, it is desirable for a mobile unit to be able to function in both ad-hoc or WWW-oriented environments and this is one of the functional specifications laid down by the IEEE 802.11 committee. When a mobile unit receives identifying beacons generated by other mobile units, it

automatically invokes the ad-hoc routines to support mobile-to-mobile communication. The mobile application controlling the network can be made intelligent enough to decide which communication mode, i.e. ad-hoc or WIG, best suits the service requirements.

The specification of the order of quality of service importance has to be mapped to the underlying routing protocol as well. After the mapping, it is possible to append such quality of service requirements into the BQ and LQ control packets 18 during the full and partial route discovery processes so that the destination node 24 can be informed of the desired quality of service requirements. In particular, during a RRC process, it is desirable for the pivoting node 64 to retain the user specified quality of service requirements that it has learned during the processing of the earlier BQ control packet 18 so that this information can be appended in the LQ control packets 80 to be broadcast.

Global Message Transport Method.

The proposed network method of Global Message Transport (GMT) concerns data communication either in mobile or in global networks amongst mobile communication units equipped with data processing and limited-range radio communicative means.

The main disadvantage of the a.m. local message transfer method is the short range of communication units' transmitting means and limited hardware resources of and processing means.

To spread the message transferring ability of radio-communicative devices operated separately or joined into mobile network.

To surmount those disadvantages an additional device is placed into the mobile wireless network, comprising the communicative mean - Cybiko Wireless Internet Gateway (hereinafter CyWIG), data storage mean and powerful (maybe static) processing mean (typically personal computer or server) connected to local and/or global network. This device is a variety of gateway between mobile wireless network and global

network. At the same time it is a data storage mean with the large capacity.

The CyWIG collects and stores current information about portable devices active in the in its range (FIG. 12, 13). It can relay messages addressed to accessible mobile devices within its range. To relay messages to the external addressees CyWIG uses the attached processing mean connected to local / global network. If the external addressee is unavailable, CyWIG stores the message in storage mean and makes additional attempts to send it later on (FIG. 14).

The same way the external messages sending from local / global network can reach the addressees in mobile network.

Output Power Control Method.

The technical result lies in increasing flexibility of output power control, improving connection quality, lowering power consumption and reducing of device overall dimensions and weight.

A known method for output power control in retransmitting relay device presumes setting a lot of output power levels, and once a day to learn session rate quality connection, on the base of this estimation choosing appropriate power output level remaining constant throughout the session.

Shortcomings of the method are: complexity of the hardware and software decision, considerable duration of procedure, necessity of base station presence.

Another known method for output power control in mobile phone supposes that all control functions are assigned to base station, with further transmitting directive notes about power level output for each mobile unit.

Drawbacks of the method are: placement of all hardware and software resources for said method realization on base station, which haven't strong limits of overall dimensions, weight and power consumption and assigning to base station all managing functions on estimation, selecting and setting processes. This

method doesn't fit portable devices since they are not managed by base station.

Activity description.

Switching on higher output power level is carried out in the next cases:

- the presence of indicator about replying power level raising in the inner device list field,

- on receiving a ping-signal from device in irregular time intervals and/or with the lower value of Received Signal Strength Indicator (RSSI), than predefined as satisfactory signal quality. In this case the device is marked in internal list as demanding higher output power level for transmission,

- a signal is received from a device with the value of RSSI lower than predefined one as satisfactory signal quality. In this case the device is marked in internal list as demanding higher output power level for transmission,

- block of information received from a device contains special indicator in its header, demanding to raise power transmission mode. In this case the device is marked in internal list as demanding a higher power for transmission.

- on sending message at raised power special flag is set in block of information header, requiring raised power for reply.

Transmission on regular power level is performed in the next cases:

- the absence of label demanding the raised power level in internal list special field,

- if the information received from a device contains indicator for regular power reply mode in its header. In this case mark for raised power reply mode in internal list is cleared.

- if the information received from a device with the value of RSSI exceeding predefined level of signal satisfactory quality and with indicator not demanding raised power reply

mode. In this case the mark for raised power reply mode in the list is cleared.

- if information received from a device with the maximal value of RSSI and with indicator demanding raised power reply mode. In this case the mark for raised power reply mode in the list is cleared.

Use of two levels of RSSI as threshold values for quality of received signal for transmission power switching. Predefined level, used as lower bound of satisfied quality of signal and maximized value of received signal level.

Devices that have received that signal add or refresh the data about the source device in it's special list of all visible devices in the area of radio coverage.

Each device during process of data exchange estimates the received signal quality of each partner in the range coverage.

Device can transmit information on normal or raised power level.

If ping-signal is received from a device in irregular intervals, exceeding predefined value then the device is marked for transmitting at raised power level mode.

If signal from a device is received with the value of RSSI less than predefined value then the device is marked for transmitting at raised power level mode.

If reply is to be sent on raised power level then special indicator is set in the packet header to show it.

If packet received from a device has raised power indicator set then the device is marked for transmitting at raised power level mode.

If packet from a device has raised power flag cleared then mark for transmitting on raised power level for the device is removed.

If packet from a device has raised power flag cleared and the value of RSSI is high then mark for transmitting on raised power level for the device is removed.

If packet from a device has raised power flag set and the value of RSSI is maximal then mark for transmitting on raised power level for the device is removed.

Fail Safe Operating System Method

The invention belongs to electronic technology, particularly to digital data file structures for the operating systems intended for use in devices with a limited hardware resources.

An prior art method of increasing fault tolerance consists of creating backup copies on the carrier. This method is realized, for example, in the file system FAT12 (MS DOS), FAT32 File System Specification etc. The whole carrier is being divided into two areas: the File Allocation Table (FAT) area and the data area. In case of damaging FAT area the whole carrier is considered as damaged. To protect prior art systems from failures the FAT area contains two extra copies of allocation table, supposing that only one allocation table could be damaged at once. However the physical reliability of the carrier itself is the key factor of positive stability of the FAT12 system. Fat 12 requires rewriting all the file data even if a little portion of data was changed. That's why the multiple rewriting of data wears out all the carrier's surface. For the carriers with a small recording cycles resource this data saving rule reduces the carrier's life.

The method of present embodiment concerns minimizing a number of recording cycles to data carrier with the caching of the data shorter than one solitary block of the carrier's memory, to provide a high fault tolerance of the file system. The technical result consists of a protection of the file system against abrupt interrupts in work.

The said technical result is achieved by dividing the carrier's surface into a data blocks of equal size and format.

Each block of the carrier is assigned status attribute (busy/free) for recording; file identifier; block identifier; data fullness of the block. The format of the first block of the file additionally have the file name. At its start-up the system assigns to each set of the logical block numbers their corresponding physical number from 0 to Nmax. In case of a block failure to record data, the system searches for another block - allowed for recording and make data record into that block. The system marks the failed block with a special attribute and assigns the physical number of the failed block to the block, in which the record was actually made.

The proposed file system of block carriers has a number of advantages before the prior art system. The system has neither special areas for catalogues allocation, nor file allocation tables (FAT) or other specialized technical information in separate area. On failure of the block, an internal reassignment of the logical block numbers is applied affecting the physical block renumbering. However the blocks reassignment table is not stored anywhere between the sessions of the file system and is being restored at each operating system (OS) initialization.

At abrupt power outages or hardware damages only the block, which was cleared or partly recorded may turn out to be in an incorrect condition. This block appears to be cut off, shorter than expected.

Logical rules to restore the file system in this case are well known. The restore can be made completely automated.

In a proposed file system all blocks of the carrier are assigned by the file system as accessible, have an identical format:

1. The attribute of the block occupation. This attribute shows that block contains data. Otherwise block is considered as a free.

2. The file identifier, means belonging the block to particular file.

3. Logical number of the block.

4. The data fullness of the block. Amount of data recorded in this block.

If a block is the first block of a file, than it has a record (as initial data) of the following file attributes: file name, file creation date, access attributes.

Thus, each block of the carrier contains information whether it is occupied or free, and if it is occupied, than under which logical number it is added to the chain making up a file. Availability of this information makes it possible building in RAM structures required for a fast access to each block of a particular file positioned on the carrier at initialization of the file system.

Frequency Division Multiple Access Method.

Proposed method allows the maximal use of assigned channel band for increasing total data exchange speed, decreasing the idle time by means of dividing of all or a part of assigned band into two or more frequency channels with the further assigning them different functions in the data exchange process.

The method lies in assigning for each frequency channel special type(s) of job(s) to be processed at.

The method lies in assigning for at least one of frequency channels functions of processing and exchange of accountant data (hereinafter "base" channel)

Other channels (hereinafter "operative" channels) are assigned for different types of job to process, for each one type of job is assigned to or more operative channels.

Periodically the communicated device interrupts its work and switches to the base channel to sent an self account data and receive environment's account data.

The account data may include the device's ID plus occupied channel number.

Every device keeps the list of account data of all devices in range and refreshes it periodically.

The account data list contains at least the device's ID plus channel number to sent messages for it.

A broadcasting (with no addressee) may be hold on all channels. A broadcasting message will be received by all devices present on the channel.